Communications
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ACCORD Broadband ATM Satellite Experiment (BASE)

-DS3 Ka-band channel

by

Isabelle Labbé, Louis Gravel, Gérard Nourry, Corey Pike, John Butterworth, Gretchen Bivens, Sean Lanigan and Brian Spink

CRC TECHNICAL NOTE NO. 97-008

December 1997
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Canada

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Gérard Nourry *(DRX)*, **Corey Pike** *(DSST)*
and John Butterworth *(DSAP)*
Communications Research Centre

and

Gretchen Bivens *(Rome Lab)*, **Sean Lanigan** *(Rome Research)*
and Brian Spink *(Rome Lab)*
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ABSTRACT

A Broadband ATM satellite Experiment (BASE) was carried out between the Communications Research Centre, Canada and Rome Laboratory, USA during the period of May 95 to March 96. The objectives of the experiment was to perform a series of tests to characterize ATM over broadband satellite bearers.

This document reports on the second portion of the first phase of the experiment that was conducted from July 95 to September 95 over the NASA ACTS satellite(Ka-band). Tests consisted in measurements of ATM Quality of Service (QoS) parameters such as Cell Loss Ratio (CLR) and Cell Error Ratio (CER) as a function of Bit Error Rate (BER). In this report, the results are presented for two different modulations (QPSK and 8-PSK) and compared against theoretical curves. Results show that Ku- and Ka-band satellite channels have similar ATM behaviour. Results suggest that applications using ATM over burst error channel will experience greater difficulties for a given bit error rate than they would on a random error media. The characterization of the breaking point remains, however, application dependent. Moreover, the broadband channel and its embedded sub-channels have been found to be coherent. As suggested in the first portion of the experiment, this result confirms that the characteristics of the sub-channels can be inferred from the broadband channel and vice-versa.

RÉSUMÉ

Une expérience de satellite MTA à large bande a été effectuée conjointement par le Centre de Recherches sur les Communications (CRC) du Canada et Rome Laboratory des Etats-Unis, de mai 1995 à mars 1996. L'objectif était de procéder à une série de tests afin de caractériser les liens satellites MTA à large bande.

Dans le présent document, il est question de la deuxième partie de la première étape de l'expérience, effectuée de juillet 1995 à septembre 1995 en utilisant le satellite ACTS (bande Ka) de la NASA. Les tests ont consisté à mesurer les paramètres de qualité de service MTA tels que le ratio de perte de la cellule et le ratio d'erreurs de la cellule en fonction du taux d'erreurs sur les bits. Dans ce rapport, on présente les résultats de deux modulations différentes (QPSK et 8-PSK) et on les compare à des courbes théoriques. Les résultats révèlent que les canaux de satellite à bande Ku at à bande Ka ont un comportement MTA similaire. Les résultats semblent démontrer que les applications utilisant le MTA sur canaux caractérisés par des erreurs se produisant en groupe seront plus affectées, pour un taux d'erreur donné, que sur canaux caracterisés par des erreurs se produisant de manière plus uniforme. Cependant, la caractérisation du point de rupture demeure assujettie aux applications. Aussi, les résultats ont démontré que le canal à large bande et les sous-canaux incorporés sont cohérents. Comme cela était proposé en [1] et maintenant confirmé, ce résultat signifie que les caractéristiques des sous-canaux peuvent être déduites du canal à large bande et vice-versa.

EXECUTIVE SUMMARY

Satellite communications provide an economical means for wide area and long distance communication. Both in military and civil application, their use is increasing. With the emergence of ATM, satellite links will soon be required to support broadband ATM traffic. ATM was initially designed for fibre-optic media, i.e. a random error, low delay, and virtually error free channel. Satellite channels are characterized by a long propagation delay. Moreover, the error coding scheme used to mitigate the effects of errors on the satellite channel often generates error bursts when the error correcting capability is exceeded.

The error correcting capability built into the ATM cell header performs well over fibre links but it is not expected to be adequate for satellite channels. The Header Error Correction (HEC) field of the ATM header can correct any single-bit error and can detect occurrences of two errors. Therefore, ATM performance over satellite channels needs to be analysed.

As part of theTTCP ACCORD project, the Communications Research Centre (CRC)/ Defense Research Establishment Ottawa (DREO), Canada and Rome Laboratory, USA have performed a series of tests to characterize broadband ATM satellite bearers.

The Broadband ATM satellite experiment (BASE) was divided into two phases. The objective of the first phase was to characterize broadband ATM channels and embedded sub-channels over Ku- and Ka-band satellites. The second phase aimed at characterizing the performance of standard networking protocols such as TCP/IP over broadband ATM Ka-band satellite links.

This document presents the second portion of the first phase of the experiment: the characterization of broadband ATM channels and embedded sub-channels conducted over the NASA ACTS satellite (Ka-band). Details on the first portion of the first phase and on the second phase of the experiment can be found in documents CRC-RP-97-007 and CRC-RP-97-008 respectively.

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1.0 INTRODUCTION

As part of the TTCP ACCORD project, the Communications Research Centre (CRC) from Canada and Rome Laboratory from the USA have agreed to perform a series of tests related to Asynchronous Transfer Mode (ATM) over broadband (DS3) satellite bearers.

The objective of the first phase was to conduct Quality of Service (QoS) performance measurements (Cell Loss Ratio - CLR and Cell Error Ratio - CER) of ATM over Ku- and Ka-band satellite links. The first portion of the first phase lasted ten days and was completed in May 1995 using the Anik-E satellite. A report describes the experiment and gives preliminary results[1].

The second phase consisted in characterizing the performance of standard transport and network protocols such as TCP/IP over broadband ATM satellite links [2].

This report presents the results of the characterization of a Ka-band ATM broadband channel and its embedded sub-channels. Since the tests are similar to the ones performed over Ku-band, the experimental configuration and methodology are as described in [1]. Section 2 lists the tests conducted for the channel characterization. The results and analysis are given in section 3. Section 4 gives the conclusions.

2.0 TESTS

The test period was spread from July to September 1995, with satellite access blocks of 3 to 4 hours, once or twice a week. The various tests performed are as follows:

1. Single Channel, full duplex, using QPSK modulation, Viterbi 3/4, no Reed-Solomon (RS).
2. Single Channel, full duplex, using 8PSK modulation, Viterbi 3/4, no RS.
3. Sub-Channels, full duplex, using QPSK modulation, Viterbi 3/4, no RS.
4. Sub-Channels, full duplex, using 8PSK modulation, Viterbi 3/4, no RS.

As explained in [1], channel characterization including Reed-Solomon is very hard to achieve. Therefore, Viterbi coding alone was used throughout the tests.

3.0 RESULTS and ANALYSIS

For each test, CLR and CER measurements were plotted as a function of BER. As in [1] and for comparison purposes, the analytical curves of ATM cell discard probability for a burst error model and a random error model were also drawn. Results were gathered for both modulations, QPSK and 8PSK. Figures 1 to 4 show the results for single channel tests while Figures 5 to 16 show the results for the sub-channels tests.

The QoS results obtained over Ka-band are very similar to the ones obtained over Ku-band. For both types of modulations CLR values higher than expected were measured. As explained in [1], it was found that the use of PLCP framing embedded into the DS3 frames is responsible for these abnormally high CLR results. To confirm this explanation, tests without the PLCP framing were conducted. Figures 17 and 18 show the QoS results for QPSK Single Channel while Figure 19 shows the results for 8PSK Single Channel.

As expected from results already given in [1], the QPSK CLR values without PLCP framing are in close agreement with the analytical curve while the 8PSK remains slightly above the curve. The different methods of coding implemented in the EF Data Modem (convolutional for QPSK - Trellis for 8PSK) are likely to be responsible for this behaviour.

For this experiment, recommendations proposed in [1] were followed and the duration for the sub-channel tests was increased. The observation time was long enough to insure a cell loss count of at least one hundred for the DS0 stream. Sub-channel results obtained over Ka-band are in agreement with the ones collected over Ku-band [1]. Figures 5 to 10 (QPSK) and Figures 11 to 16 (8PSK) show that there is no significant difference between stream types. Furthermore, there is no significant difference between the QoS measurements of the full broadband channel and the ones observed for its embedded subchannels. The identical results obtained for DS3, DS0, 4DS0, and DS1 mean that the number of errors is proportional to the channel bandwidth.

As mentioned above, it was found that QoS results obtained over Ka-band are similar to the ones measured over Ku-band. However, Ka-band and Ku-band satellite channels have by nature different propagation characteristics. Samples of these characteristics are illustrated for both Ka-band and Ku-band on Figure 20. These plots show the variation (in dB's) of the carrier wave as a function of day time. Variation may be caused by various factors such as weather conditions (heavy rain, accumulation of snow on the satellite dish, ...). By comparing the two curves, one can observe that typically, Ka-band receive levels will be much more affected by those factors than Ku-band receive levels. This variation directly impacts on the Eb/No value which in turn impacts on the BER value. While performing the Ka-band channel characterization experiment, a greater degree of difficulty in obtaining a constant BER reading was in fact verified. Therefore, the only measurement periods retained were those for which a statistically valid and stable BER reading could be obtained. Having followed the same methodology when conducting the Ku-band experi-

ment, it thus seems that measurements taken when the attenuation levels remain within the operational capability of the EF Data Modem give almost identical ATM QoS results.

4.0 CONCLUSIONS

In this experiment, the characterization of a broadband Ka-band ATM satellite channel (45 Mbps) and its embedded sub-channels was performed. The most important conclusions emerging from the channels characterization are:

a. With the current experimental configuration, the Ku- and Ka-band satellite channels display similar ATM behaviour. Thus, their communication characteristics appear to be the same when measurements are recorded over a range of stable BER readings.

b. The theoretical curves show that the CLR and CER values expected in burst error channels are higher than the ones expected in random error channels. In the Ka-band as well as in the Ku-band, experimental data for burst error channels are in close agreement with the theory when PLCP framing is not present. The results suggest that applications using ATM over burst error channels will experience greater difficulties for a given bit error rate than they would for a random error media. The characterization of the breaking point is application dependent.

c. CLR results are higher when PLCP framing is embedded into DS3 frames. The PLCP frame structure is not well designed to cope with burst errors. However, if PLCP must be present, a possible solution to improve the performance could be the use of bit interleaving on the PLCP header or part of the header including the C1 byte.

d. When PLCP framing is absent, QPSK results are in agreement with the theory while 8PSK remains slightly higher. Different methods of coding (convolutional vs Trellis) are likely to be responsible for this behaviour.

e. The channel and its sub-channels are coherent. DS0, 4DS0, DS1 and DS3 ATM QoS results are identical, which means that the errors are distributed proportionally to the channel bandwidth. As suggested in [1] and now confirmed, this result implies that the characteristics of the sub-channels can be inferred from the broadband channel and, vice-versa, that sub-channels results can be extrapolated to broadband channel results.

These results are important to understand the ATM behaviour over broadband satellite links and should prove to be very useful for future work.

5.0 REFERENCE

[1] I. Labbé, et al, "Broadband ATM Satellite Experiment (BASE) -DS3 Ku-band", CRC-RP-97-007, Ottawa, December 9th, 1997.

[2] I. Labbé, et al, "Broadband ATM Satellite Experiment (BASE) -Protocols characterization", CRC-RP-97-007, Ottawa, December 9th, 1997.

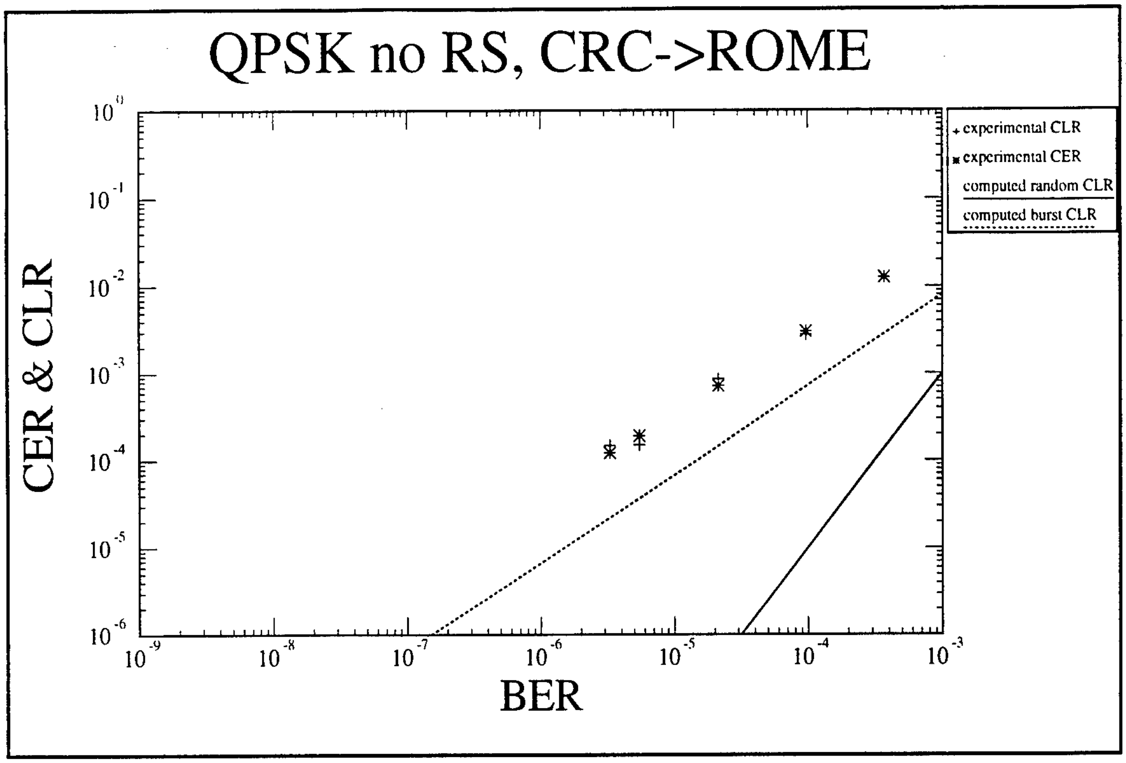

Figure1: QPSK Single channel CRC->Rome

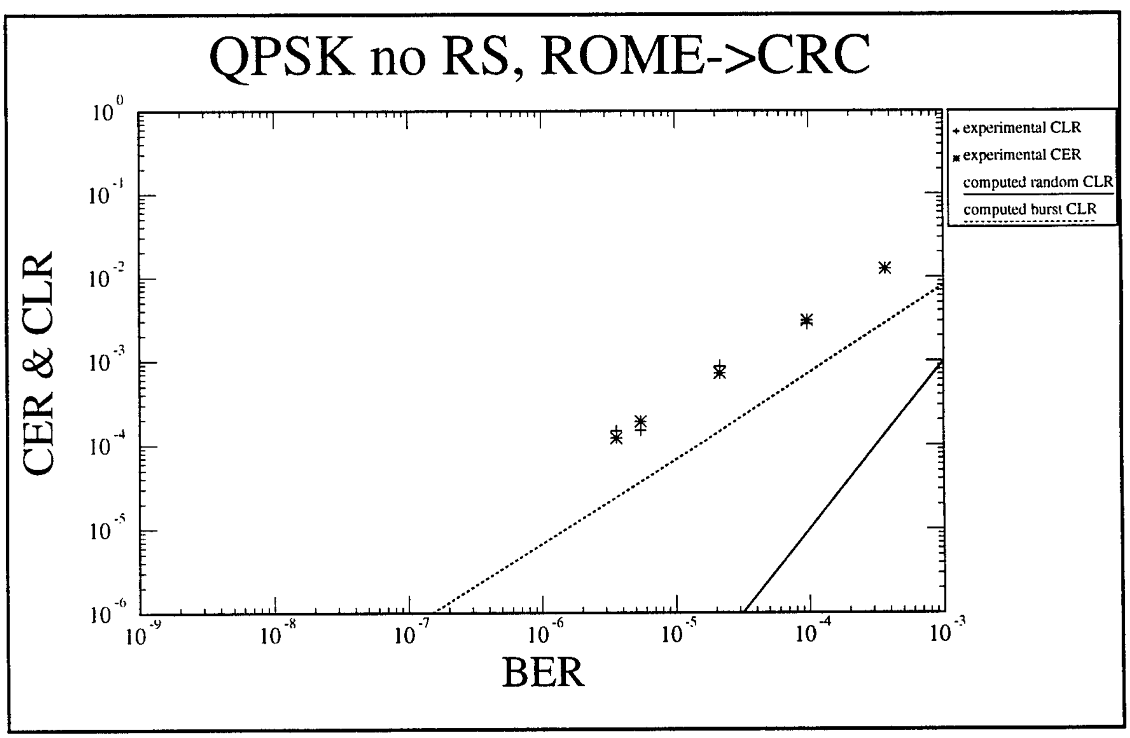

Figure2: QPSK Single channel Rome->CRC

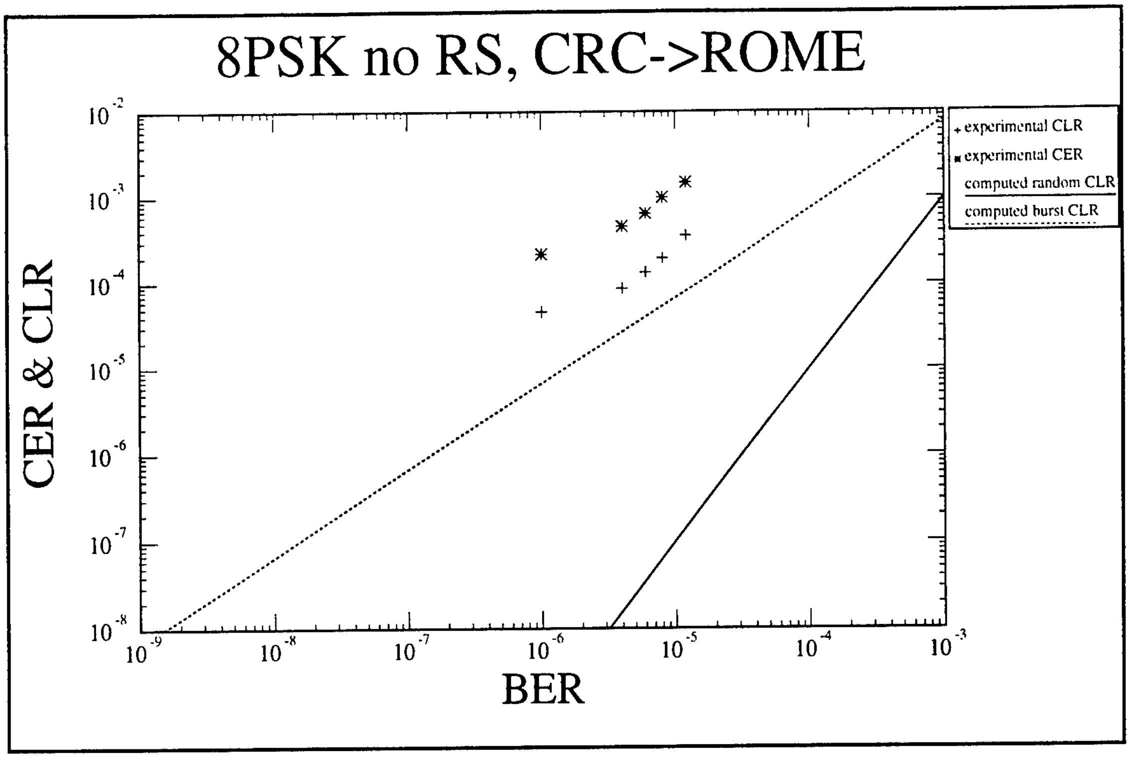

Figure3: 8PSK Single channel CRC->Rome

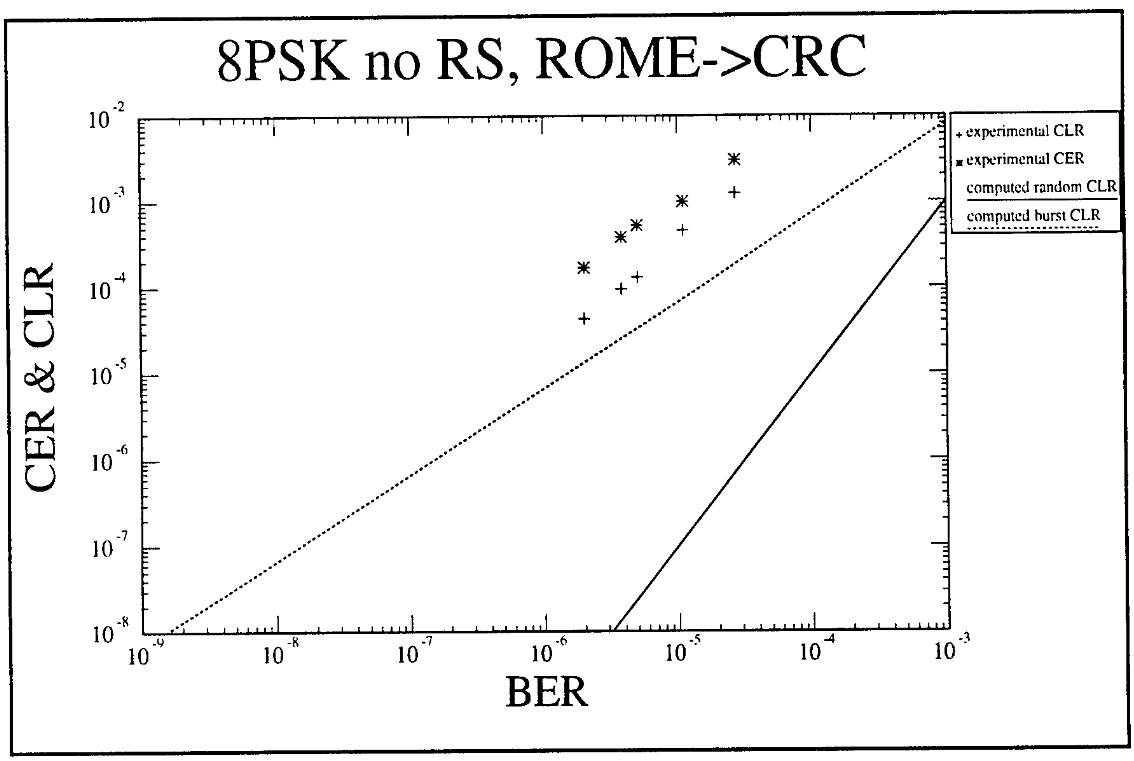

Figure4: 8PSK Single channel Rome->CRC

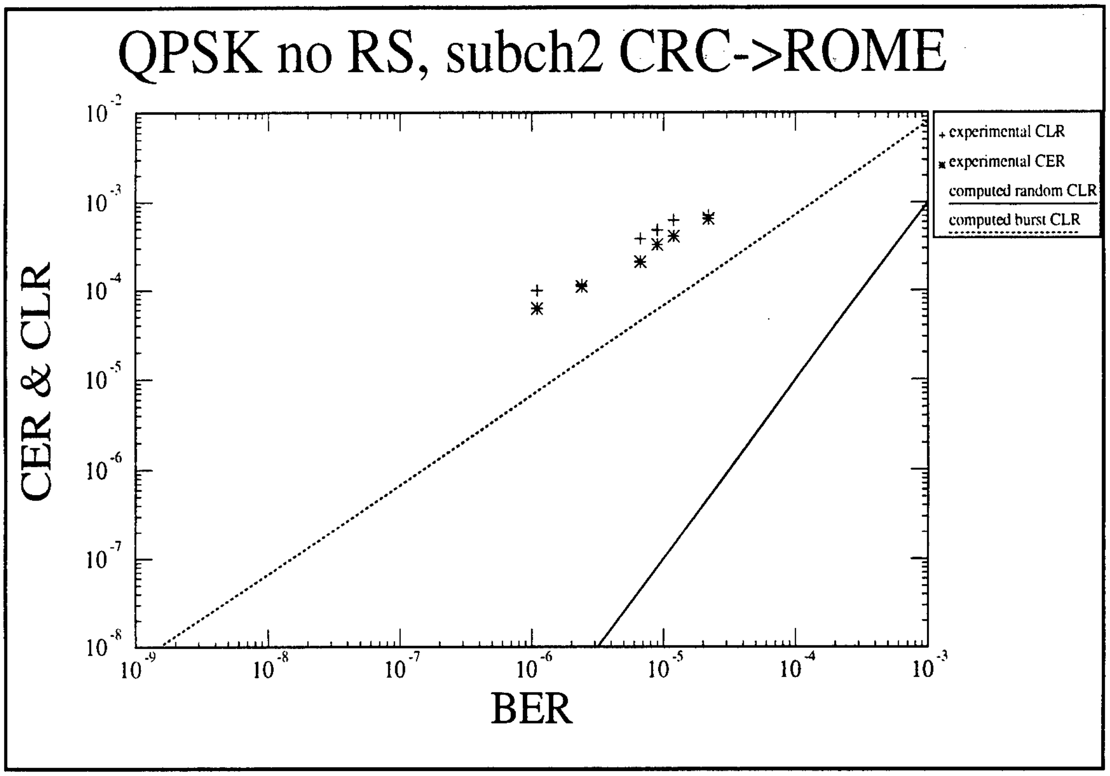

Figure5: QPSK subchannel DS0 CRC->Rome

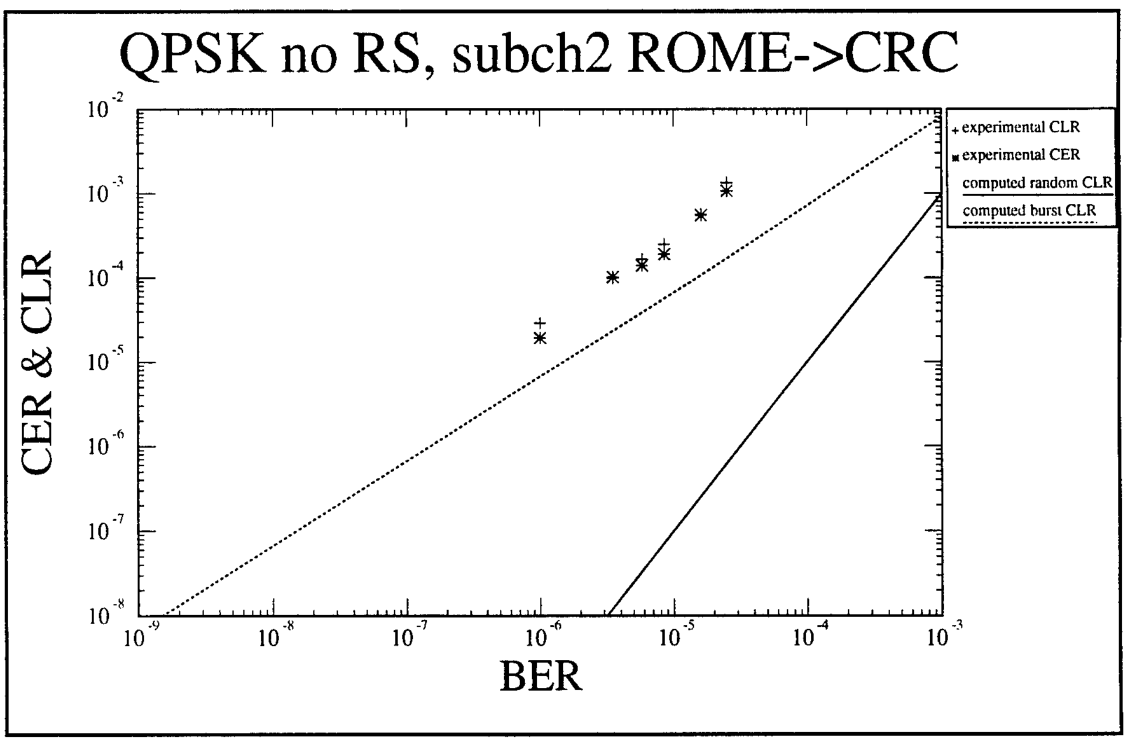

Figure6: QPSK subchannel DS0 Rome->CRC

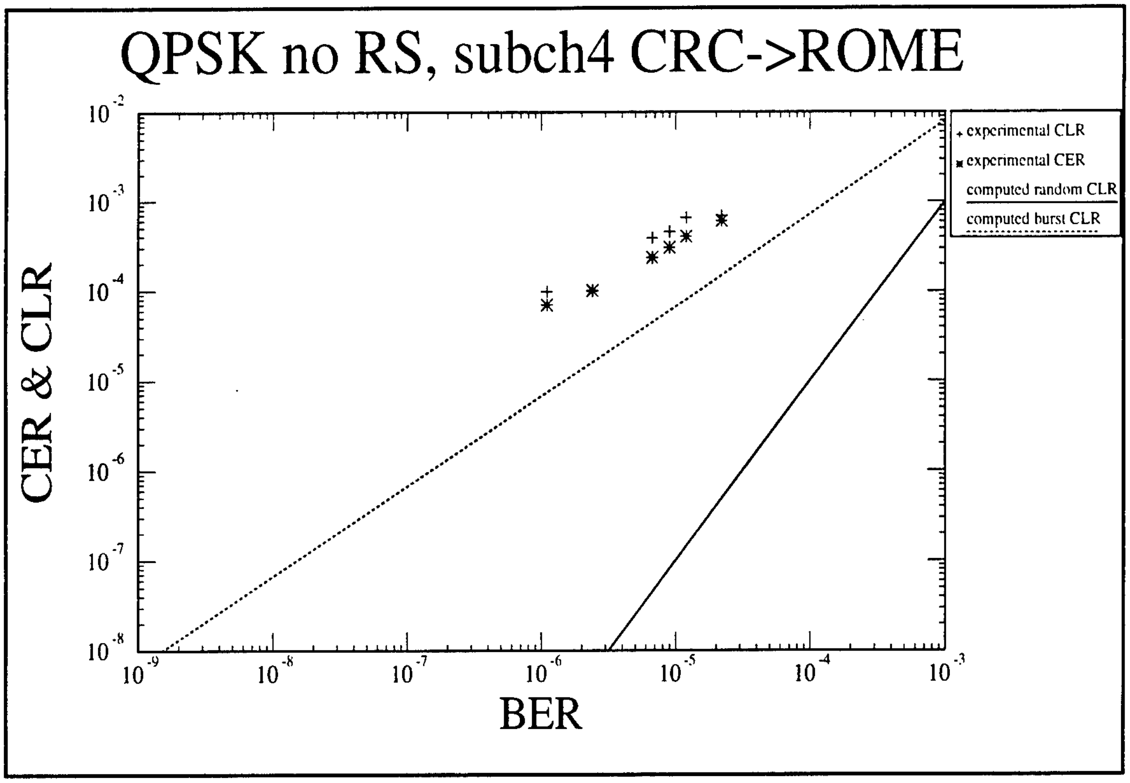

Figure7: QPSK subchannel 4DS0 CRC->Rome

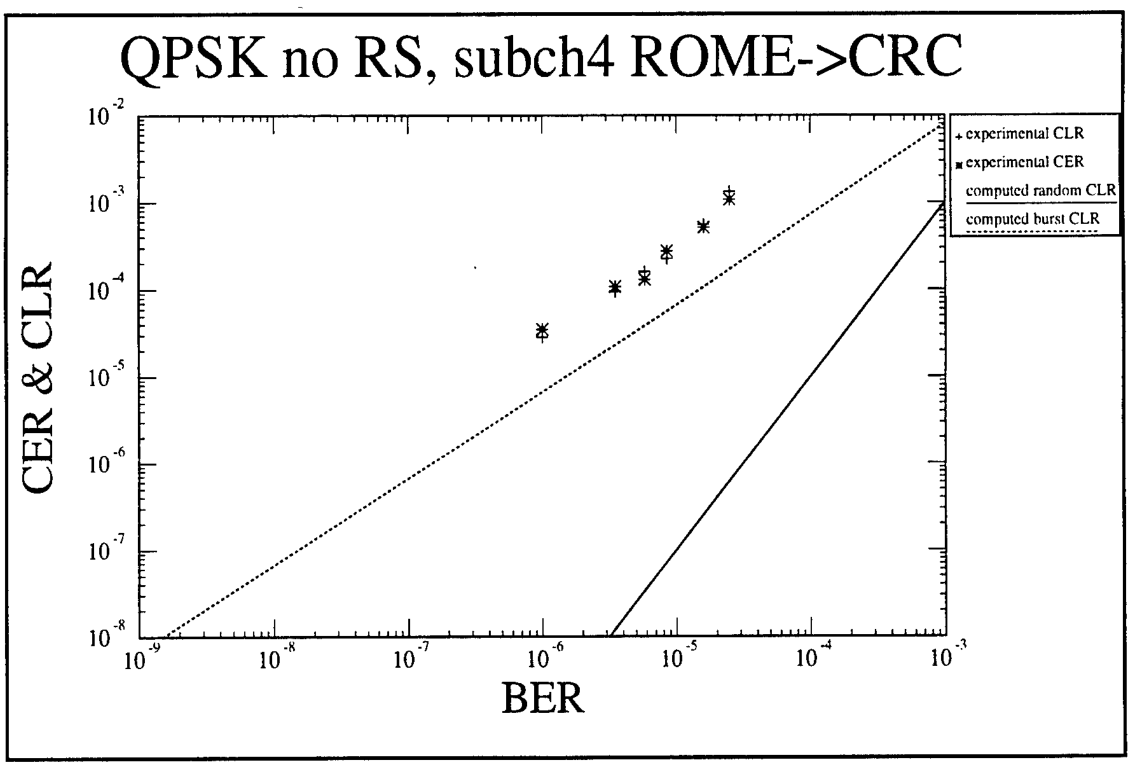

Figure8: QPSK subchannel 4DS0 Rome->CRC

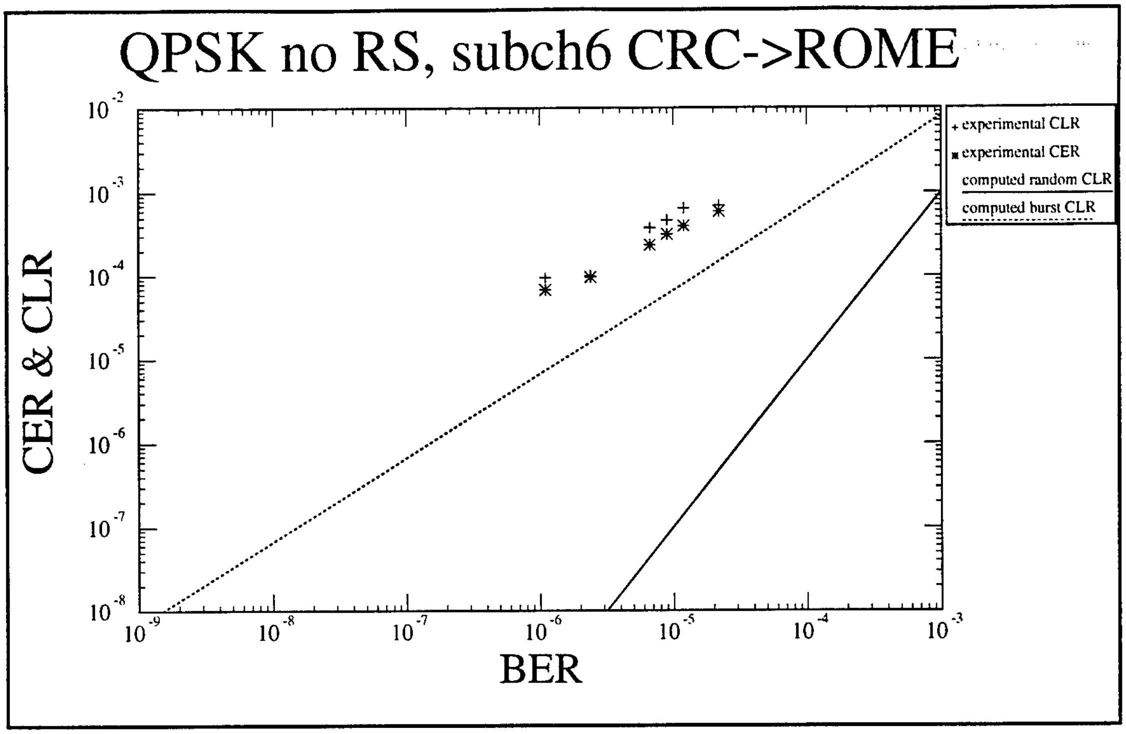

Figure9: QPSK subchannel DS1 CRC->Rome

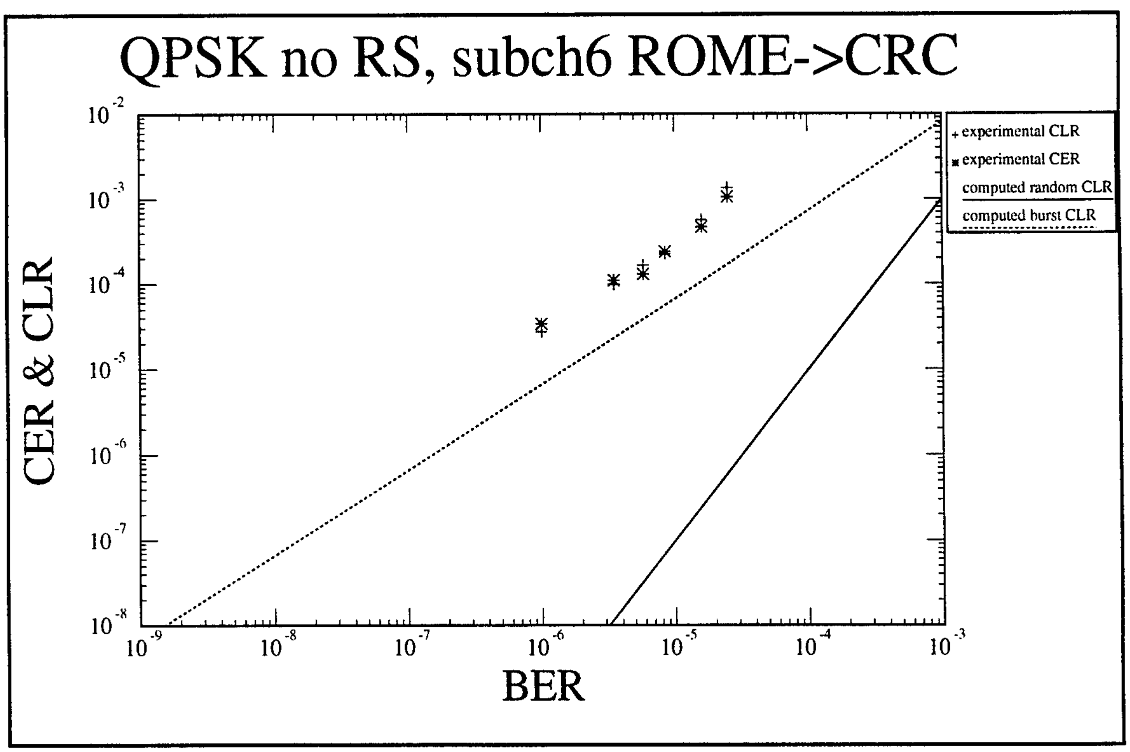

Figure10: QPSK subchannel DS1 Rome->CRC

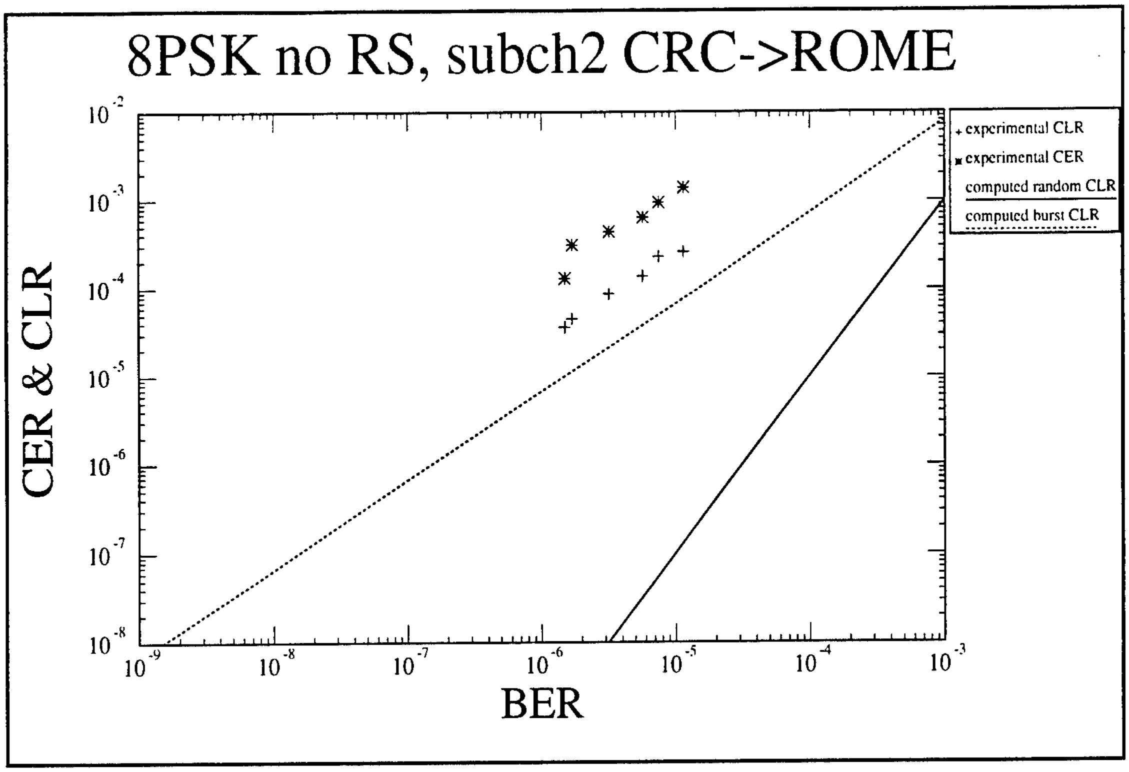

Figure11: 8PSK subchannel DS0 CRC->Rome

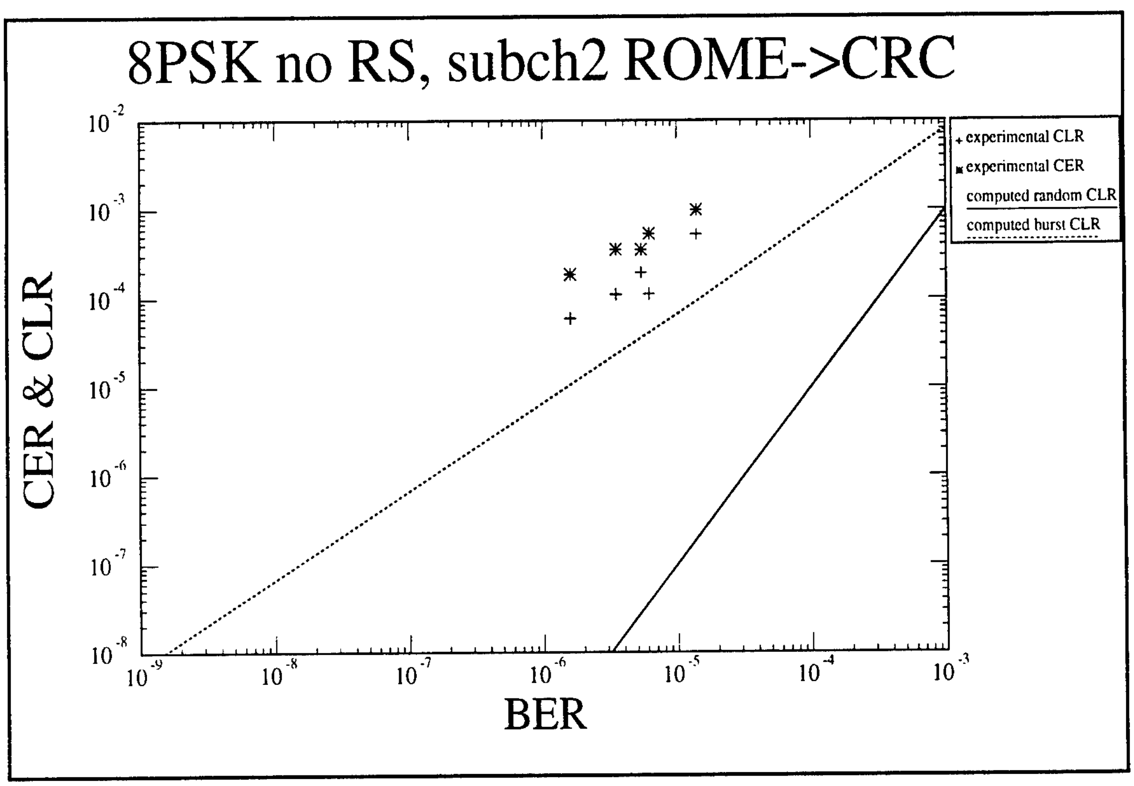

Figure12: 8PSK subchannel DS0 Rome->CRC

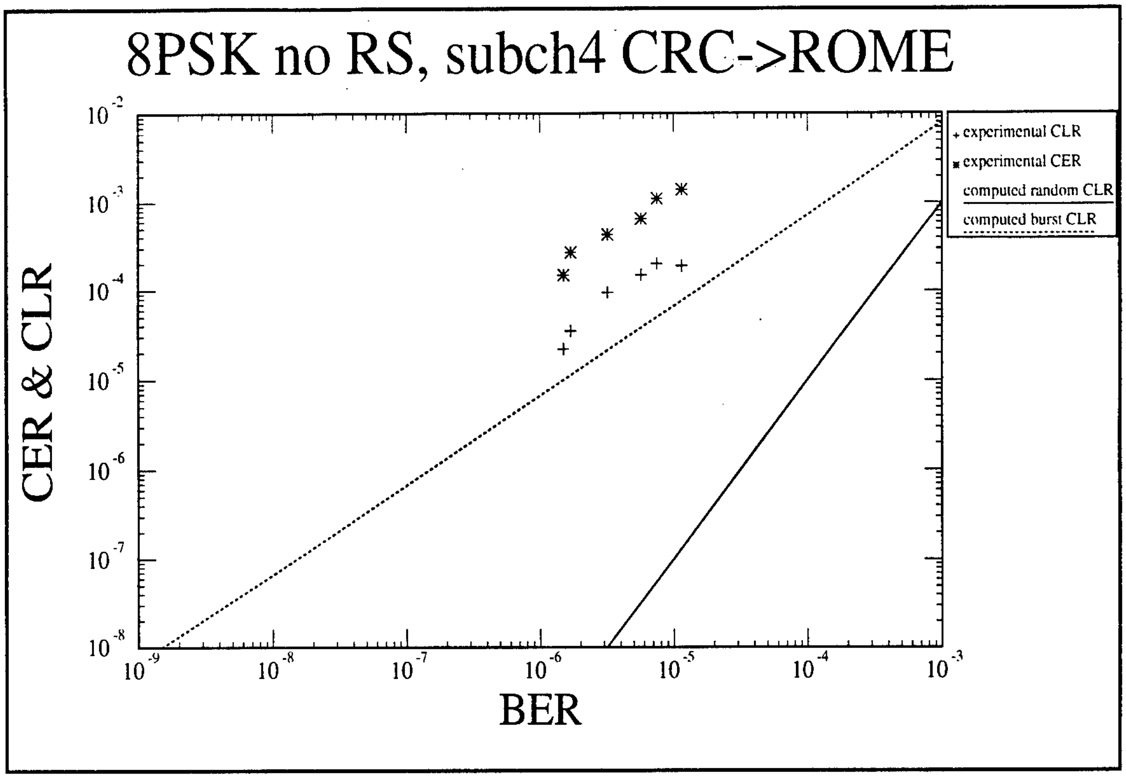

Figure13: 8PSK subchannel 4DS0 CRC->Rome

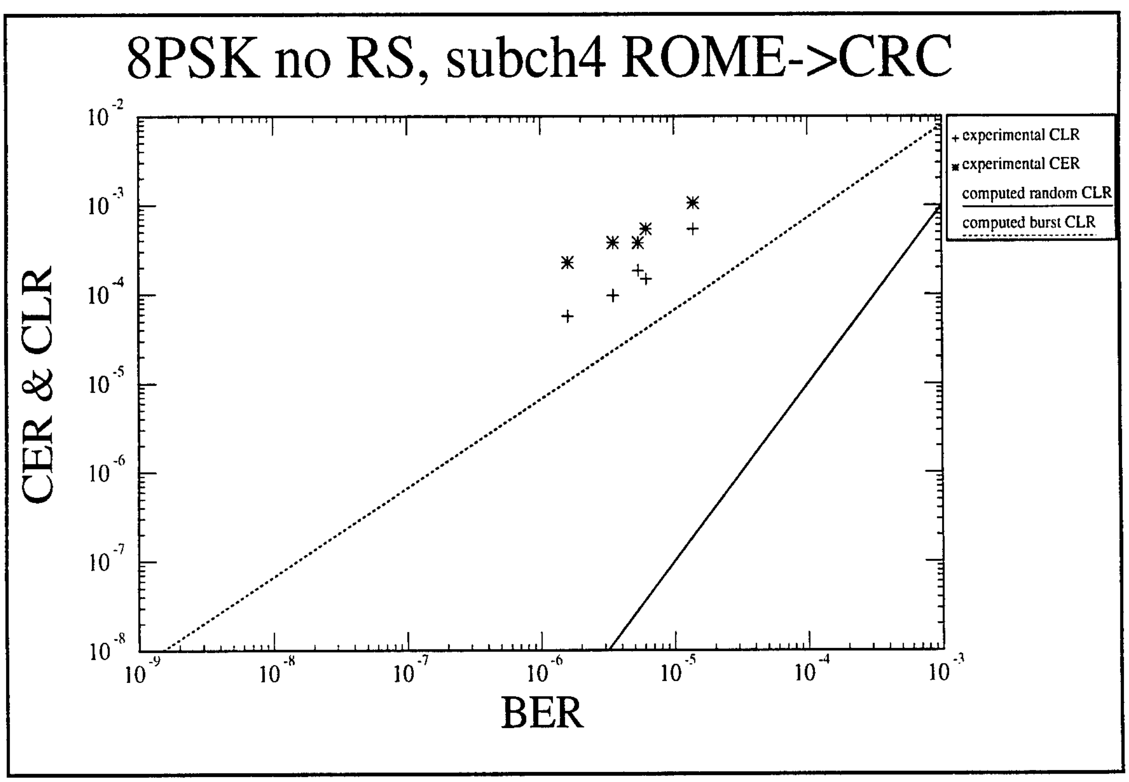

Figure14: 8PSK subchannel 4DS0 Rome->CRC

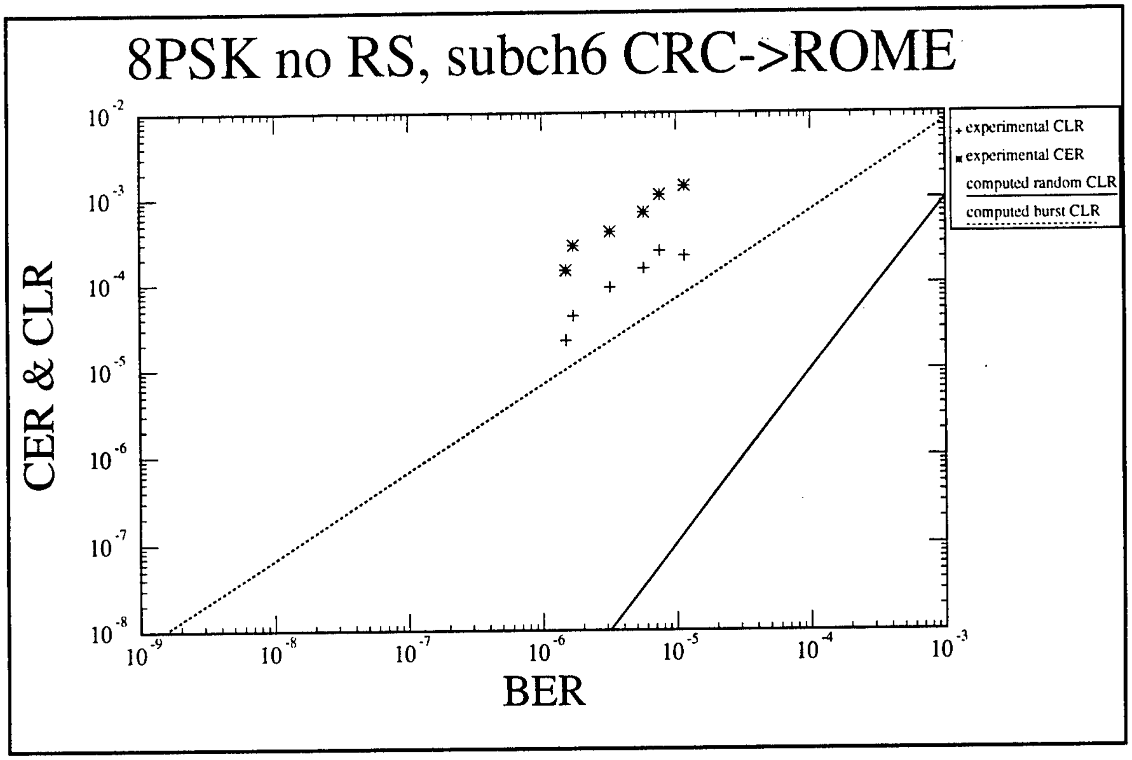

Figure15: 8PSK subchannel DS1 CRC->Rome

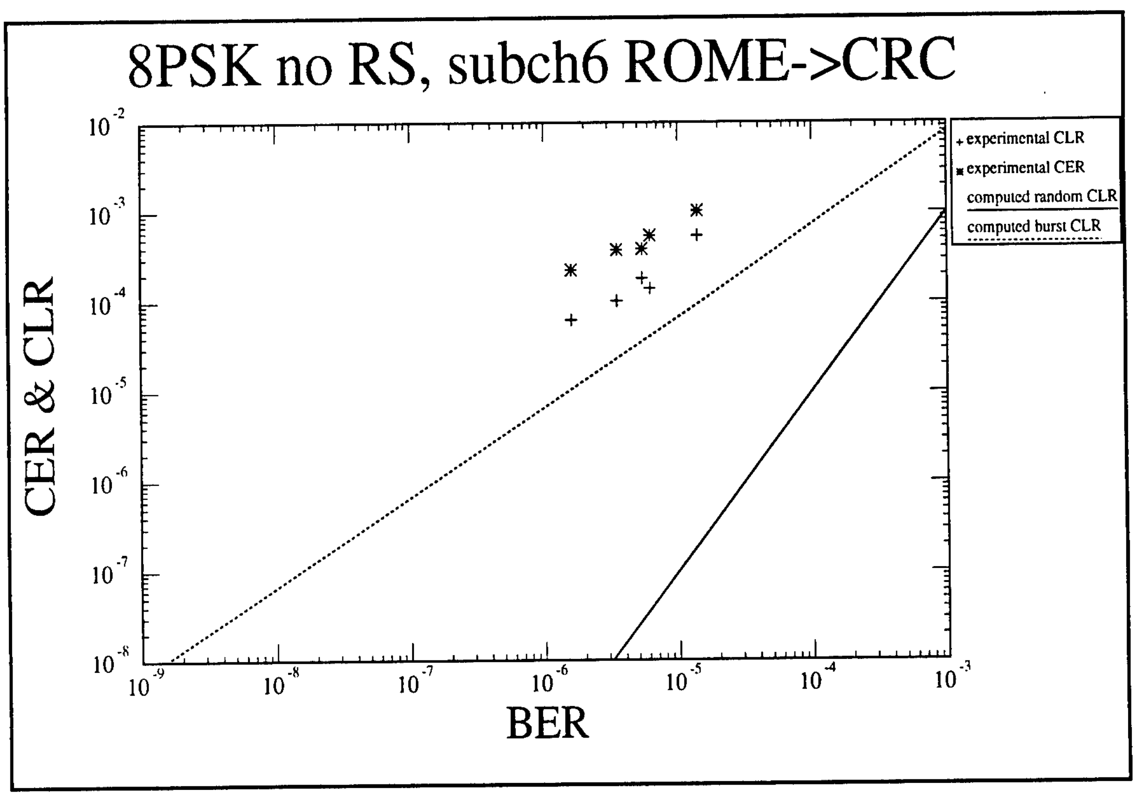

Figure16: 8PSK subchannel DS1 Rome->CRC

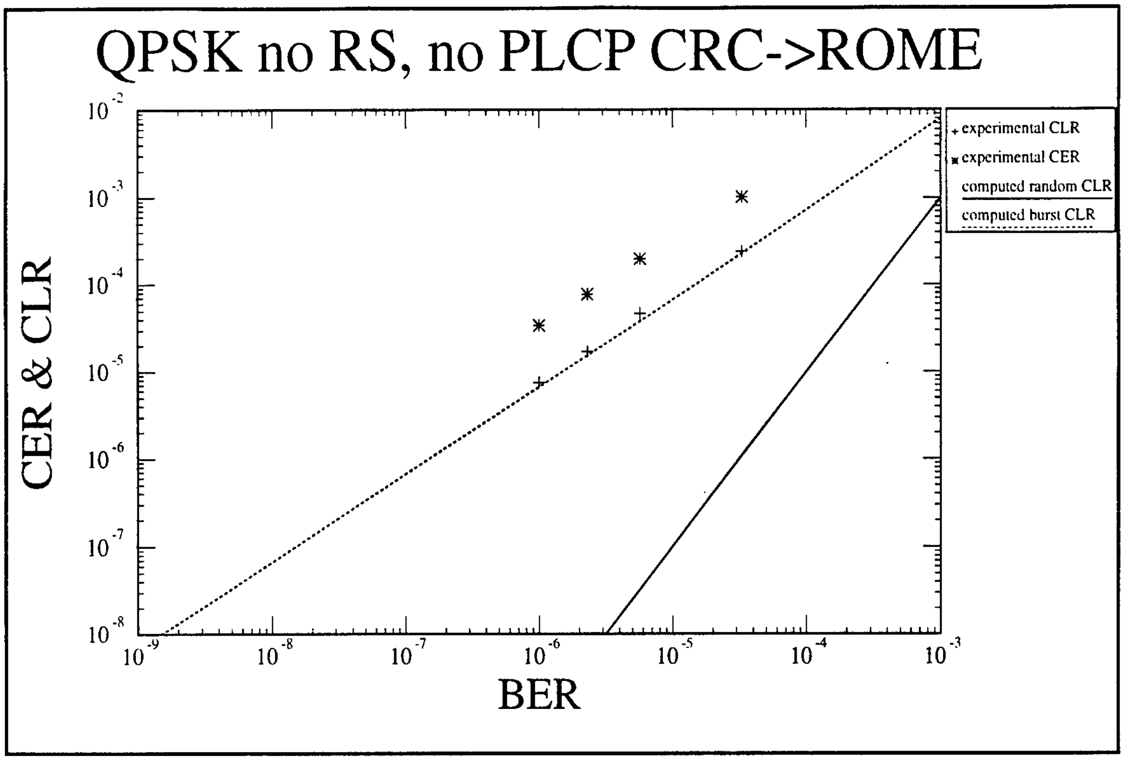

Figure17: QPSK Single channel no PLCP CRC->Rome

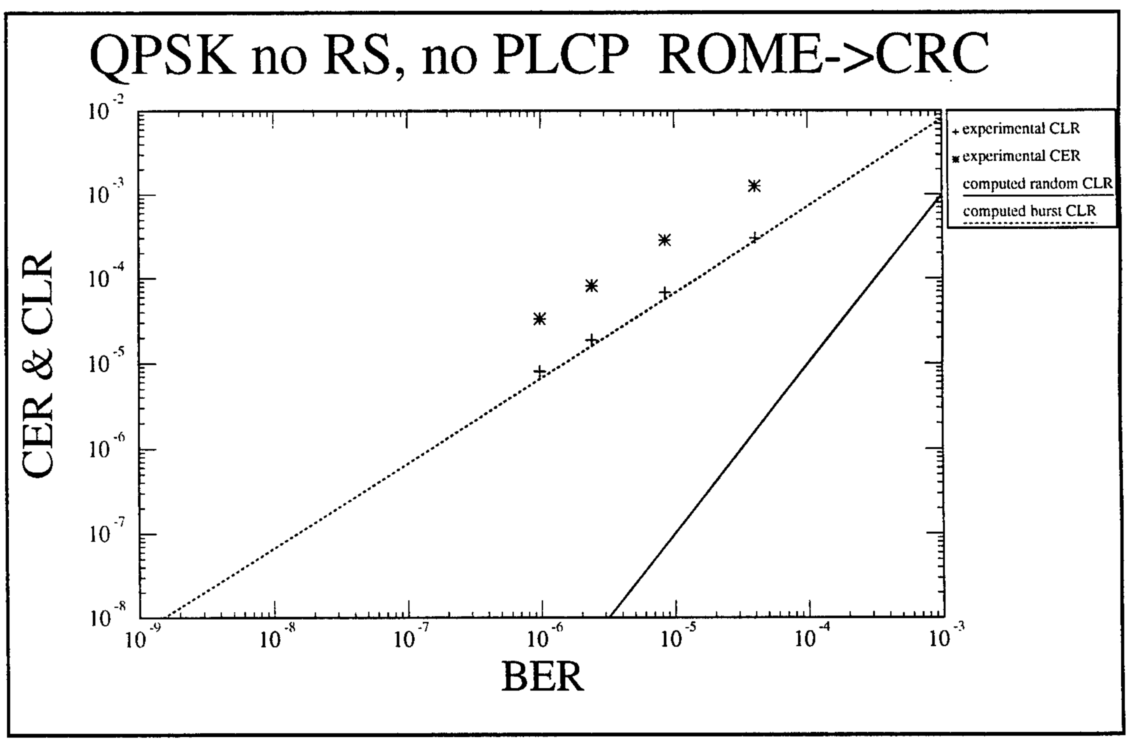

Figure18: QPSK Single channel no PLCP Rome->CRC

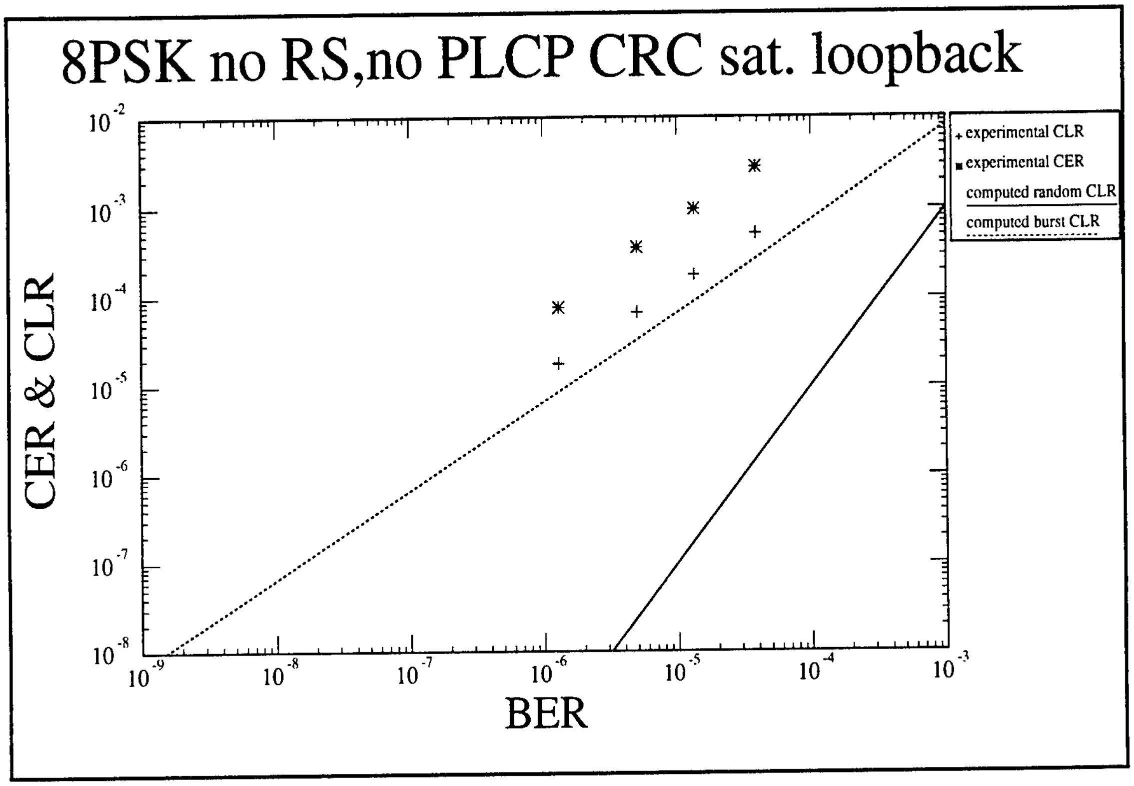

Figure19: 8PSK Single channel no PLCP satellite loopback

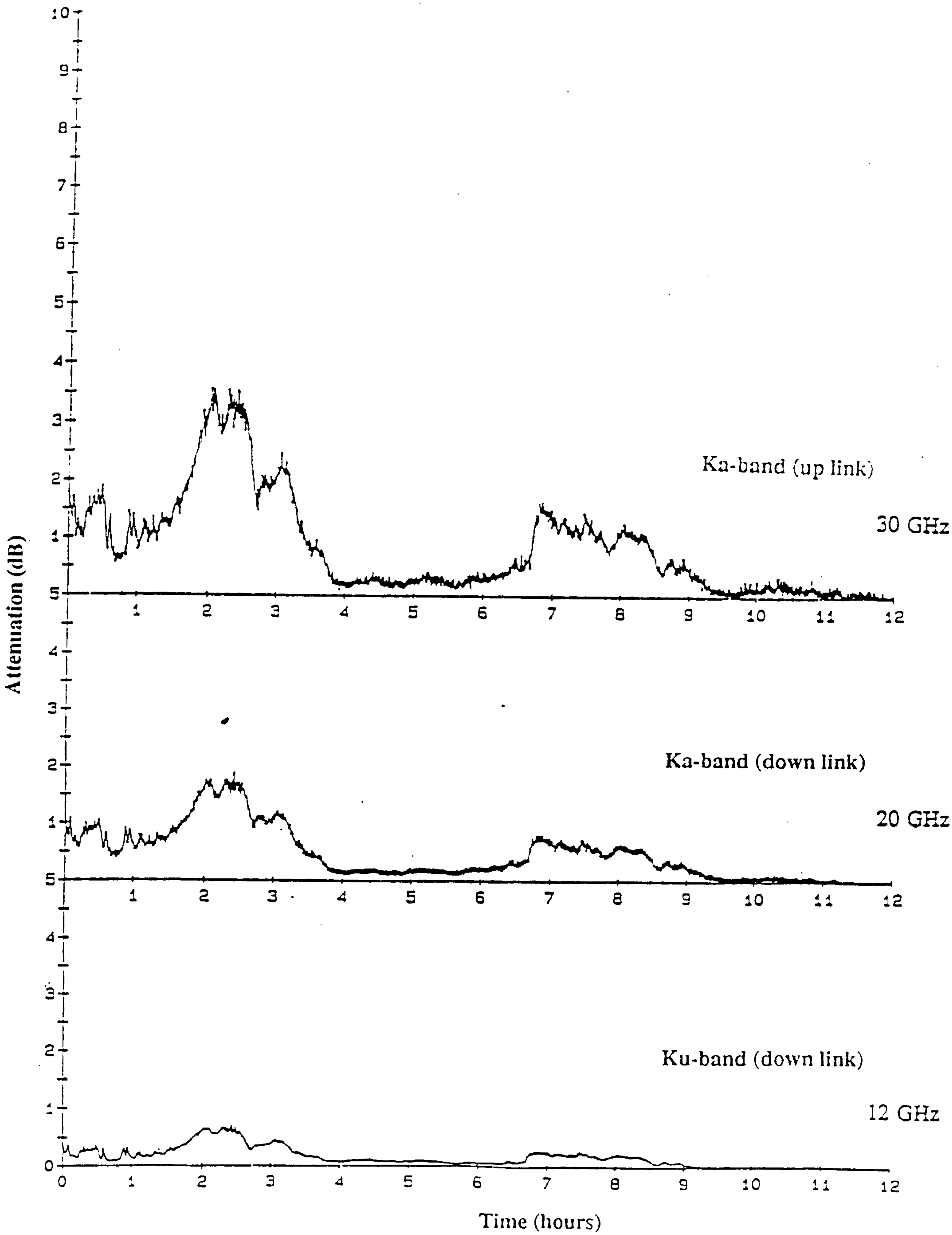

Figure 20: Radiometrically- Measured Path Attenuations, event on Feb 26, 1992.

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